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ABSTRACT

While the improvement of authoring systems and the development of knowledge-based rather than frame-oriented computer assisted instruction (CAI) systems are useful, a significant part of the courseware development problem lies in the inability of teachers (subject matter experts) to prepare material that promotes effective, efficient learning. Only those visible instructional events exemplified by "offline" independent study packages and online CAI sequences are available for review and criticism; classroom-based instruction receives no similar scrutiny. The problem does not lie solely in the development of educational technology; rather it is much more generic, existing in all instructional environments. The solution lies in developing an increased understanding of learning strategies, algorithms, and heuristics with this task falling largely on instructional system developers, and more specifically on instructional designers. The paper includes a description of courseware production problems at Athabasca University, which is a Canadian adult distance education institution, and recommendations for the development of a Canadian technology-based educational system. A summary of the paper in French is included. (Author/ESR)

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ON-LINE OR OFF-LINE COURSEWARE: THE WEAKEST LINK

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The last 10 years have seen awesome progress in the development of computer based educational systems. The increased power, decreased cost and wider availability of hardware is truly impressive. There have also been considerable improvements in author languages, authoring systems and in understanding of the computer's potential role in learning.

The excitement, pride and enthusiasm produced by these developments are well earned. But along with the successes there have been failures. The progress made in hardware and software development has not been achieved in courseware development. The literature abounds with references to courseware inadequacies and warnings that a failure to produce adequate courseware will result in another failure to implement Computer Based Education.

This paper argues that while improved authoring systems and the development of knowledge based rather than frame oriented systems is useful, a significant part of the courseware development problem lies in the inability of teachers (subject matter experts) to prepare material that promotes effective, efficient learning. The current reality in education is that only those visible instructional events exemplified by "off-line" independent study packages and "on-line" CAI sequences are available for review and criticism. Their flaws are seen and challenged. Classroom based instruction, on the other hand, receives no similar scrutiny. The position is taken that while the "bad" examples in independent study and CAI materials are indeed "bad" examples, the conclusion that we must train people to develop better materials for independent study and CAI implies that the problem is in the development of these unique materials. The authors will argue that the problem is much more generic, existing in all instructional environments not just in independent study and CAI and that the solution lies in increased understanding of learning strategies, algorithmics and heuristics rather than in easier authoring or production sytems.

The task of expediting more effective, efficient and relevant learning falls largely on instructional system developers, and more specifically on instructional designers. The paper concludes with a review of the present strengths and limits of instructional design and recommends directions for future research, practice and support from funding agencies.

DIDACTICIEL EN DIRECT OU EN DIFFÉRÉ - LE MAILLON LE PLUS FAIBLE

Au cours des dix dernières années, on a assisté à des progrès étonnants dans les systèmes d'enseignement automatisé. L'augmentation de leur puissance, la réduction de leur coût et la disponibilité accrue du matériel impressionnent. Ces mêmes années, on a également amélioré considérablement les langages et les systèmes de rédaction et l'on comprend bien mieux le rôle que peut jouer l'ordinateur dans l'apprentissage.

L'engouement, la fierté et l'enthousiasme suscités par ces progrès sont bien mérités. Mais, parallèlement à ces réussites, il faut signaler certains échecs. Le didacticiel n'a pas connu les progrès réalisés dans le matériel et dans le logiciel. La documentation technique ne cesse de signaler les carences du didacticiel et de prévenir que, faute d'y remédier, on aboutira à la faillite de la mise en oeuvre de l'éducation automatisée.

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Selon le présent mémoire, bien qu'il soit utile de créer des systèmes améliorés de rédaction et des systèmes axés sur les connaissances plutôt que sur les unités d'information, une bonne partie du problème d'élaboration du didacticiel réside dans l'incapacité des enseignants (qui sont experts dans leur matière) d'établir un matériel qui rende l'apprentissage efficace. Actuellement, dans le domaine de l'éducation, on ne dispose, pour fins d'étude de critique, que des événements visibles qui sont mis en lumière par des progiciels en différé de recherches indépendantes ou de séquences en direct d'enseignement automatisé. On peut en déceler les failles et s'y attaquer. L'enseignement en classe, par contre, ne fait pas l'objet d'un examen aussi soigné. La position adoptée est la suivante: d'une part, les "mauvais" exemples de l'étude indépendante et du matériel d'enseignement automatisé constituent effectivement de mauvais exemples; d'autre part, la conclusion qu'il faut former des experts capables de créer de meilleurs matériels dans ces domaines implique que le problème réside précisément dans l'élaboration de ces matériels exceptionnels. Certains auteurs soutiendront que le problème est beaucoup plus répandu qu'il se pose pour toutes les formes d'enseignement, et non pas seulement pour l'étude indépendante et l'enseignement automatisé; et qu'ainsi, la solution se trouve dans une meilleure compréhension des stratégies, des algorithmes et de l'heuristique de l'apprentissage, plutôt que dans la création de systèmes facilitant la rédaction ou la production.

C'est au responsable des systèmes d'enseignement, et plus particulièrement aux concepteurs en la matière, qu'incombe dans une large mesure la tâche d'instaurer un apprentissage plus efficace et plus pertinent. Le mémoire se termine par un bilan des lignes de force et des limites de la conception dans le domaine éducatif et par des recommandations aux organismes de financement concernant la recherche, la pratique et l'appui des organismes de financement à l'avenir.

ON-LINE OR OFF-LINE COURSEWARE: THE WEAKEST LINK

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INTRODUCTION

The power and versatility of computer based or computer supported instructional systems are dependent on the adequacy of four main elements: hardware, software/courseware, people and organizational structures. By far the most impressive developments to date have occurred in the hardware element. This progress is a result of massive infusions of expertise and dollars because hardware development is seen to have major economic consequences primarily in the business, industrial and military sectors. The educational sector has essentially adapted this hardware for instructional applications. The success of the hardware enterprise is characatured by a quotation attributed to one of Bell Lab's engineers:

> We are looking forward in the short term to a computer so small that it will fit into a Crackerjack box. We will give the computer away, probably, but the costs of good software will continue to increase for obvious reasons.
>
> (From Goldberg, 1982, 30)

Hardware developments are likely to continue but the software problems remain and are nowhere more acute than in the educational sector. This paper will focus on software/courseware problems and propose a strategy for dealing with the elements that are required for the development of a technology-based educational system.

It is our view, consistent with Bunderson (1981), that the current educational system has achieved a level of productivity beyond which it cannot go, that is, it has reached its own maximum of improvability. If we expect to obtain the quantum leaps in productivity and quality output that appear necessary in the near future, we must call upon the power of the "micromillienum" to assist in the task of revamping the educational system. As Bunderson states:

> When education is analysed into the work that is required, technology is seen to be the only way to make a fundamental difference (1981, 96).

It is important to note that in this paper, technology and its applications to educational systems development is viewed in the broadest sense, that is, as both process and as hardware. Our concern is not that we implement computer-assisted instruction (CAI) or computer-assisted learning (CAL) in the schools, colleges and universities but rather, that we draw upon CAI or CAL as well as computer managed instruction (CMI) and the process technologies such as instructional design (ID) and instructional systems design (ISD) in the careful reorganization of our educational system. In this manner both the tremendous progress in electronic hardware technologies and, ultimately, the process technologies can be brought to bear on problems of efficiency, effectiveness, and accessibility facing our educational system.

EXAMPLES OF COURSEWARE PROBLEMS AND SOLUTIONS

During the last 20 years, the major developments in computer based educational systems have come through a few large, government funded projects. Kearsley (1983) reviews these projects and identifies a number of important contributions that they have made. Of particular interest for this paper, are the courseware authoring languages like TUTOR, NATAL, PILOT and the development of authoring systems. These products appear to be contributing to courseware developments of some merit. Some courseware, for example, from Computer Curriculum Corporation (CCC) and from Control Data Corporation's PLATO is commercially available and in widespread use. Further developments of authoring languages and systems is on-going and will likely contribute to improvements in courseware in the near future.

The development of authoring languages and systems is one of the responses to the continuing and increasing demands by the educational sector for more and better software and courseware. In the past few years, most provinces in Canada have made micro computers available in schools and educational institutions at all levels. The increased availability of hardware and the increased demand for courseware clearly justifies the emphasis computer vendors are placing on making their products easy to use and their claims about how simple courseware is to develop. Indeed teachers are being told that they should be developing courseware, and new authoring microcomputer languages are appearing rapidly.

The development of languages and systems to assist in preparing courseware are necessary and desirable, however, they may also be contributing to the problems of poor quality courseware. By making instructional courseware design and production thereby appear to be easy and possible, indeed, an activity in which anyone can engage, is contributing to an increase in the volume of courseware, but not to a concomittant consistent improvement in quality.

A number of authors have addressed the problems of courseware production by novices. Hall, for example, describes the tendency for teachers to produce "on-line lectures which the student observes" (Hall,1983,1) and the probability that "computerists" will use the hardware for "pyrotechnical displays". He is particularly concerned with the lack of attention to appropriate use of questioning and the lack of intellectual engagement between the student and the instructional material. Roblyer (1983) also addresses the issue of courseware developed by novices. She focusses on the characteristic flaws of teacher-produced instructional courseware and notes that errors are common in both instructional design and computer programming. She says that few teacher-produced products have data collection facilities adequate to ensure empirically based revision and validation. While acknowledging some exceptions, she notes that little of this courseware is broad enough in scope or accompanied by appropriate manuals and documents that permit the potential user to place the courseware in the context of the curriculum. Gagne, Wager and Rojas (1981) consider CAL courseware developed using an authoring language that depends upon standard prompts consisting of: TEXT - QUESTION - FEEDBACK - (REMEDIATION) - TEST. They acknowledge the fact that such systems can help authors develop courseware packages but they are concerned about the ease with which such systems permit the author to ignore both hypothesized internal learning processes and external instructional events and to produce the same instructional sequences regardless of the learning outcome desired.

Gagne et al use a table of these processes and events (see table 1) as well as a description of the types of learning outcome (verbal information, intellectual skills, cognitive strategies, motor skills and attitudes) in proposing a methodology that could assist courseware developers in appropriately preparing the text or presentation part of a CAI sequence.

Table 1

Internal Processes of Learning and the External Instructional Events Which May Be Used to Support Them

Internal Learning Process	External Instructional Event
1. Alertness	1. Gaining attention
2. Expectancy	2. Informing learner of lesson objective
3. Retrieval to working memory	3. Stimulating recall of prior learning
4. Selective perception	4. Presenting stimuli with distinctive features
5. Semantic encoding	5. Guiding learning
6. Retrieval and responding	6. Eliciting performance
7. Reinforcement	7. Providing informative feedback
8. Cueing retrieval	8. Assessing performance
9. Generalizing	9. Enhancing retention and learning transfer

From, Gagne, et al, 1981, page 19

Roblyer (1981) draws some critical distinctions between the processes of authoring and designing courseware. She focusses her attention on the importance of using an instructional design process rather than an individual teacher authoring approach. She argues that an instructional design process which is characterized by:

1. the use of a theory-based model;
2. an emphasis on written documents;
3. a team approach to development;
4. provision for formative review and evaluation;

will have a significantly higher probability of producing effective and efficient courseware than will an individual authoring approach.

Instructional design approaches do have considerable support. However, they are also subject to increasing criticism because of a tendency to depend heavily on behavioural theory and models. Sprague (1981) for example, draws attention to Gagne's shift towards a cognitive approach (Gagne and Briggs, 1979) and draws attention to the inter-relationship among Gagne's learning outcomes, Harmon's response hierarchy (1979) and Bloom's taxonomy. In summary, Sprague notes that the trend towards incorporation of cognitive theory is positive, however, he advises that the original elements from behavioural theory should not be forgotten, particularly the systematic approach, task analysis and use of instructional objectives.

THE ATHABASCA UNIVERSITY EXPERIENCE

There is a growing body of knowledge and theory from both applied and research activities that will need to be drawn upon in addressing courseware production problems. Athabasca University, an adult distance education institution, has now had more than eight years of experience in an attempt to implement the process of instructional systems design within the context of the whole institution.

The attempt, while not a total failure, cannot be viewed as a complete success. In large measure, the systems approach and the application of a theory-based model to the preparation of instructional courseware has produced a substantial impact on the quality of course materials. These are primarily, print-based home-study or independent study materials with some use of audio-visual and broadcast media. The materials are delivered to students in their homes and human interaction is provided primarily through telephone tutors.

The materials are produced using an ISD-theory based model. There is an emphasis on written documentation, a team approach has been used extensively and provision is made for formative review and evaluation. However, there is an increasing resistance to the theoretical basis, particularly the behavioural elements and there are considerable pressures to forget the model and "get it done". Further, while written documentation is required, there is an increasing trend towards superficial and incomplete analysis and documentation. The team approach, which in the past, saw subject matter experts, instructional designers, editors and visual designers collaboratively producing courseware, is rapidly giving way to subject matter experts (authors) providing materials to editors or instructional developers to "fix-up". Finally, while provisions are made for formative review and evaluation, it rarely occurs because of time pressures, physical production models and costs.

In addition to the flaws in the courseware production process, there are also problems with the linkages between the systematically produced courseware and the other elements of Athabasca University's instructional system. There is a general failure to link the processes of needs analysis, curriculum design, course development, course delivery and evaluation/revision. The tenuousness of these connections effectively ensures that the systems model is not functionally implemented, but rather, only some of the requisite elements exist in rudimentary form.

Why the failures? As in any human endeavour, difficulties exist in organizational structures, value system conflicts and economic and social realities. The problems at Athabasca University are not unique, they are not even unusual. The conflict between the traditional models of teaching and instructional design models is not difficult to see. The former might be characterized as saying "I teach and if you don't learn, so be it!" while the latter, characterized by a student centered orientation, a mastery model and criterion-referenced evaluation is more likely to say: "Analyse the student needs and the learning outcomes, assemble the resources, arrange the conditions, empirically observe the outcomes and revise to fit!".

In addition, the implementation of the systems approach at the University has not been without flaw. There has been some over-dependence on the "peanut butter cookie recipe", that is, an effective, if dull, arrangement of "objectives - presentation - practice - feedback - testing" as well as a somewhat narrow dependence on behavioural models. Also, there has been an almost complete focus on materials development to the near exclusion of student management procedures.

These difficulties are not due to a lack of knowledge. There are a number of resources available to instructional designers both to assist in the implementation of the instructional design process and to bring to bear more of what is now known about human learning processes. Dick and Carey (1978) and Briggs and Wager (1981), for example, have produced handbooks of instructional design. Merrill and Tennyson (1977) have provided a similar resource for the design of concept teaching sequences. Brien (1983), Jay (1983) and Tennyson (1982) attempt to translate new information from cognitive research for application in instructional contexts. Although still in an early stage of development, Rigney and Monro (1981) describe some activities in the area of learning strategies which should lead to new knowledge about how to prepare instruction that will assist students in acquiring, retaining, and retrieving representational and procedural knowledge. Additionally, work by Landa (1982) and Mitchell (1980) in the development and validation of algorithms and heuristics should also provide new knowledge for instructional applications in courseware development.

It is important to recognize that the problems described about both Athabasca University off-line courseware and teacher-produced on-line courseware are not confined to technology-based instructional applications. We can assume that similar inadequacies exist in the "invisible" instruction that occurs in the classrooms, seminars, workshops and laboratories of our educational system. One compelling advantage of the experiences at Athabasca University is the opportunity to really observe the instructional process and the awareness it has produced about current instructional inadequacies and the limitations of current models and theories.

The developments described by Kearsley (1981) in never "knowledge-based" rather than frame-oriented authoring systems, potentially offer substantial assistance to courseware designers. These systems should provide both research and production help. But he also notes that the rate and extent of this development is to some extent dependent on prior additions to the knowledge and theory base in cognitive science.

RECAPITULATION

In summary, neither authoring languages nor attempts to implement an ISD model has, to date, unambiguously improved the quality of efficient and effective learning experiences. A number of directions have been suggested for improving on this situation. Specifically, it has been argued that the ISD approach does have considerable merit, that resources are available for at least applying what we know and improving on implementation of an ISD model and finally, some research activities have been identified that appear likely to produce knowledge and theory to enhance courseware development efforts.

These suggestions may be seen as useful in the effort to address the problems of courseware development. However, one may also be skeptical of the likelihood that they would be implemented within the current individualistic, project-based and institutionally constrained educational models. Further, courseware is a critical component, but is only one component in a technology-based educational system. Equally important are: hardware, people and organizational infrastructures. While discussing these elements is beyond the scope of this paper, it should be noted that much is being learned about them as well (Kearsley,1982; Szabo and Jensen,1983). However, the knowledge being acquired with respect to all four major elements - courseware, hardware, people and organizational infrastructures may be "too little and too late". While the continuing and accelerating pressures created by hardware infusions throughout the educational sector should not be permitted to stampede us into applications beyond our own capabilities, it seems imperative that we proceed more rapidly and more systematically to address these issues.

A PROPOSAL

In order to meet the challenges and move towards a technology-based educational system we need to address problems in three areas:

1. We need to rapidly increase the application of what we now know and to fill the "knowledge gaps" that exist with respect to developing effective and efficient courseware. This research function could and should move quickly towards the development of a courseware industry.

2. We need to disseminate what we now know and gain more knowledge about the human and organizational issues involved in "technology transfer".

3. We need to work with the electronics industry to ensure that educational systems development is informed by and draws upon the "best" available in this rapidly changing industry.

To date all of these issues have been addressed in fragmented, piecemeal fashion. Some very desirable and useful outcomes have emerged. However, it seems inplausible that even the most successful courseware of technology-based projects will strongly influence activity on a macro scale. While there is merit in incremental, small-step approaches, there is also need for larger scale, perhaps even national scale activity. In Canada, we have some relevant national scale activities of note, for example, the developments of NATAL, Telidon and the Canadian Educational Computer. These are worthy projects. However, in terms of the elements required for a technology-based educational system, they focus on hardware and software development with little attention to courseware, human and organizational infrastructure issues.

The complexities and problems of shifting from our current creakingly archaic educational system to a new model that uses the advances in electronic and process technologies to assist us in our "educational work" are enormous. Further, they impinge upon a variety of social, cultural and value system issues as well. Most of the current projects and activities are characterized by long start up periods in which vested interests, threatened managers and naive staff have to be pacified, mollified and carefully assisted in the acquisition of relevant skills. These are important concerns in the implementation of any new technology, however, perhaps there are ways to militate their impact on the developmental process.

Governments, business and industry, and the university research community have modelled an approach which could be adapted to address the problems faced by the educational sector. Specifically, they have established Research or Discovery Parks in which experts, drawn from all relevant areas, work collaboratively to solve problems. Their solutions, in the form of products, processes and services, are then marketed by the contributing agencies. Why not a similar approach to the implementation of technology-based education? This would require the gathering together of researchers and practioners from a variety of fields such as education, psychology, linguistics, computer-science, business and management. Housed together, or perhaps linked electronically, these people could focus their attention on the most critical problems and design, develop and produce courseware; plan, organize and implement projects; and market these products and services both nationally and internationally. The potential marketability of courseware and instructional models developed in such a manner is high. Many English and French speaking countries face similar problems in their educational systems, and while we in Canada do have jurisdictional issues to address, they are less, at least quantitatively than those of our neighbors to the south.

The viability of educational research parks will depend on a variety of issues. Since education is a public sector enterprise, clearly, governmental involvement will be required. Indeed, at least initially, such a park would require direct funding from governmental sources. However, the enterprise would at least have the potential for income generation and could, under some circumstances, become partly self- sufficient. Cooperation would be a prerequisite, not only among the experts hired to participate, but also, in all probability, among and between governments - both provincial and federal. This cooperation may not be as difficult to effect as some may think. There are a number of indicators that our politicians and civil servants recognize this need to cooperate.

Currently, for example, the four Western provinces, the Yukon and Northwest Territories are about to sign a distance education agreement which will include the sharing of learning materials, technology - product and process - for applications to distance education. This is a particularly important event because one jurisdiction could provide the fiscal support for the development of the application while the other jurisdiction would have to show a willingness to suspend the "not-made-here" caveat.

CONCLUSION

Some authors have suggested that we should continue to formulate our questions and conduct research within the framework of traditional classrooms and that we should not concern ourselves with the ultimate directions our educational system might go. Further, such authors advocate a focus on the appropriate uses of the new technologies (eg. Lewis, 1980). While we agree that question formulation, research and appropriate uses of technology are important, we do not see continuing incremental applications of computer-based education in traditonal classroom contexts as either adequate or desirable.

We believe that the social, economic, political and technological realities facing our educational system do not allow the luxury of this classical, academic posture. We are suggesting that a research and development paradigm shift is required enabling all of the elements to be addressed in a holistic manner. An environment conducive to "technology transfer" - from basic research, through development to finished products is required. An organizational structure and incentives need to be put in place which will bring all the relevant actors together into symbiotic relationships in order to break the current pattern of simplistic applications of computers to solve massive educational problems. These are essentially policy and human issues - perhaps the weakest link of all and the least amenable to a "technological" fix.

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